Extracting Coherent Information from Noise Based Correlation Processing

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LONG-TERM GOALS

The goal of this research is to establish methodologies to utilize ambient noise in the ocean and to determine what scenarios are best suited for applying these methods.

OBJECTIVES

Because noise-based correlation processing is based on equilibrium related stationary statistics, the ocean does not really provide a cooperatiing scenario for such processing. The objectives of this research is to develop array and signal processing that overcome the effects of the fluctuating ocean by essentilly developing techniques that speed up the processing to time scales shorter than those of ocean fluctuations.

APPROACH

The approach has been a combination of experiment/data analysis and the development of appropriate signal processing methods.

WORK COMPLETED

Reference [1} is an outgrowth of our noise correlation processing in which the acoustical structural and scattering properties of an object can be determined by noise measurements. Reference [2] is an outgrowth of our noise measurements originally originally taken from CTBTO arrays. Here the vector sensor emulation is extended to higher frequencies. The research referred to in Reference [3] is a spinoff from a fish tank experiment in which our noise correlation methods were applied to the buildings ambient vibrations in which the tank was located. We showed that we were able to determind the acoustical properties of tank from this ambient noise. This work has been reported in Reference [4]. Large at-sea experiments were conducted and the results will be analyized and reported on in the near future.

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RESULTS

We have worked out the theory of determining the scattering properties of an object by taking measurement of the body immersed in a random noise field. The theory is confiirmed with COMSOL finite element calculationsas shown in the eample figure for both the impedance matrices and the scattering.

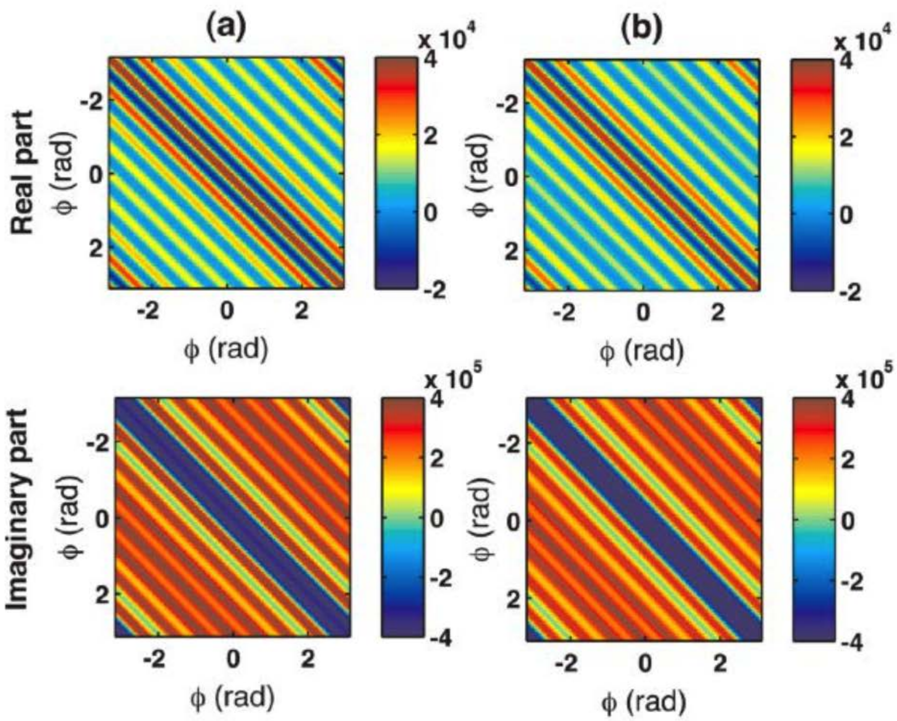

FIG. 4. (Color online) Structural impedance matrix (Pa s/m) at 100 surface nodes for a lossy cylindrical shell with damping $\eta_1 = 0.05$. (a) Numerical result with pseudo-inversion of $\langle \mathbf{vp}^H \rangle$ performed with the 18 largest eigenvalues. (b) Analytical solution using nine modes.

Figure 1

We have recently done experiments on an instrumented shell that was produced by a 3D printer (a new experience for us). The shell was instrumented as shown in Figure 3 and the preliminary results confirm our theory. These will be reported in the future.

Finally, we have recently conducted at – sea experiments (see for example Figure 4) to measure the effect of fine scale oceanography on noise and propagation. Results will also be reported out after analysis. These also were opportunities for graduate students to participate in large scale ocean acoustic experiments.

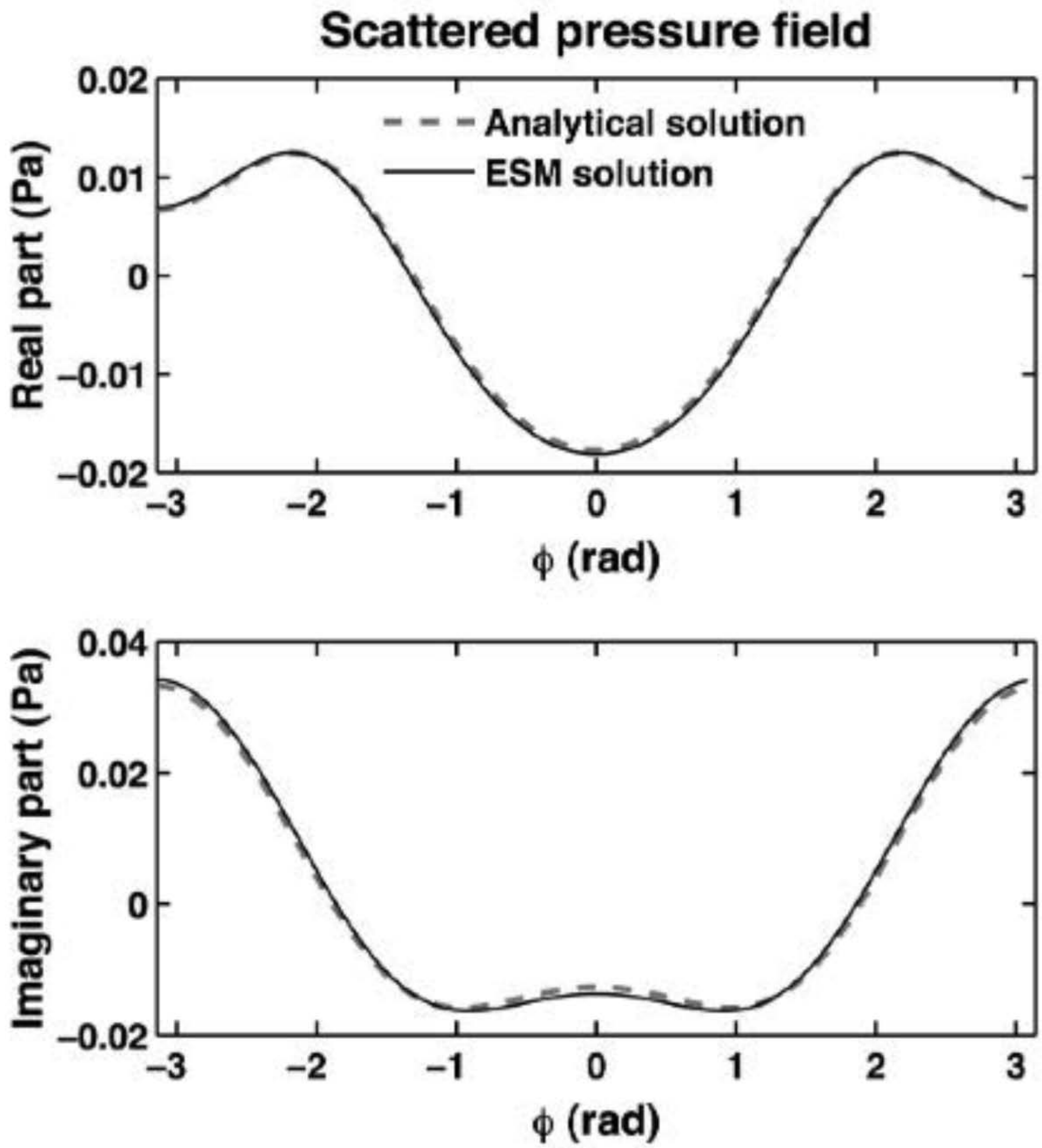

FIG. 6. Comparison of the scattered pressure fields from the equivalent source method (ESM) with the analytical solution when the cylindrical shell is excited by a 2D point source at 2 kHz. The point source is located at 3 m from the center of the shell. The scattered pressure field is plotted for receivers located all around the shell at 0.4 m from the center of the shell. The ESM solution uses 100 equivalent sources and the structural impedance matrix (Fig. 4) numerically evaluated using the correlation process.

Figure 2

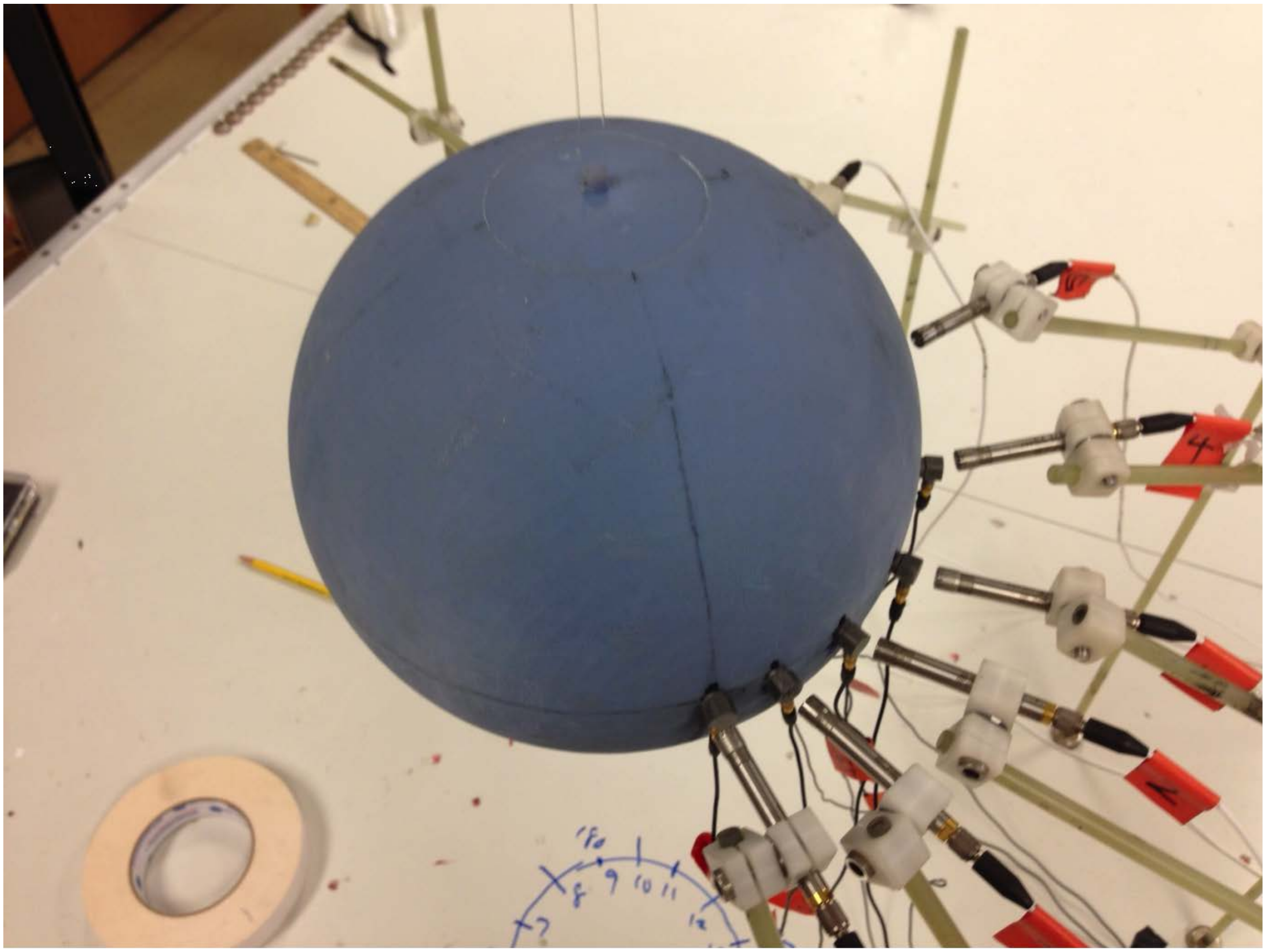

Figure 3

IMPACT/APPLICATIONS

The potential impact of this research is directed toward developing passive methods to study ocean environmental acoustics.

RELATED PROJECTS

None

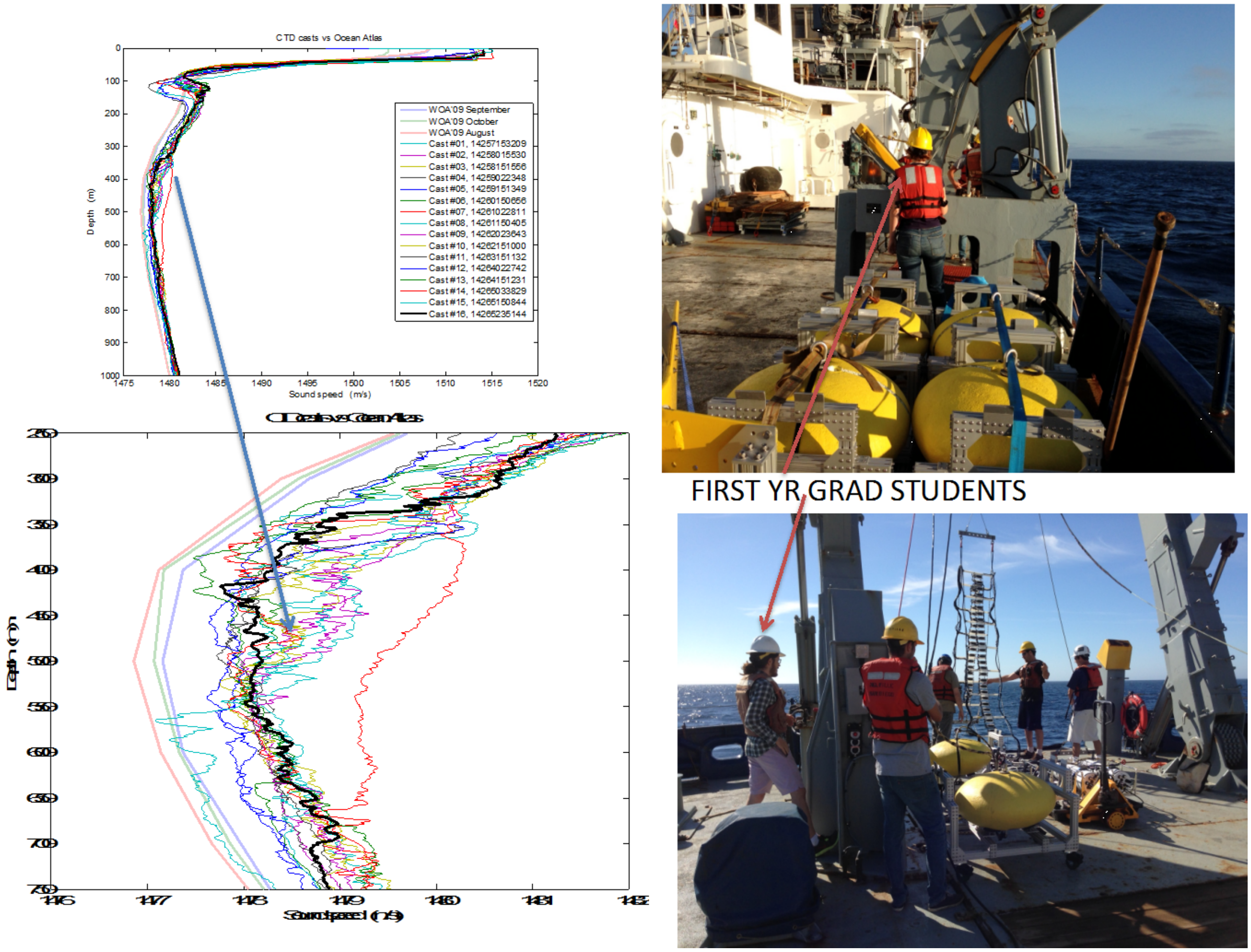

Figure 4

PUBLICATIONS

[1] "Prediction of a body's structural impedance and scattering properties using correlation of random noise,"Sandrine T. Rakotonarivo, W. A. Kuperman and Earl G. Williams , J. Acoust. Soc. Am. **134** , 4401 (2013) ; http://dx.doi.org/10.1121/1.4828833

[2] "Using hydrophones as vector sensors," Selda Yildiz, LeRoy M. Dorman, W. A. Kuperman, Karim Sabra, Philippe Roux, Dale Green, Stephanie Fried and Henrik Schmidt J. Acoust. Soc. Am. **135** , 2361 (2014) ; http://dx.doi.org/10.1121/1.4877778

[3] "Target localization through a data-based sensitivity kernel: A perturbation approach applied to a multistatic configuration." Selda Yildiz, Philippe Roux, Sandrine T. Rakotonarivo, Christian Marandet and W. A. Kuperman, J. Acoust. Soc. Am. **135** , 1800 (2014) ; http://dx.doi.org/10.1121/1.4868362

[4] "Model Tank Measurements and Using a Random Noise Feld to Determine the Scattering Properties of an Object." Sandrine Rakotonarivo, Selda Yildiz, Philippe Roux, Earl Williams, and W. A. Kuperman, Underwater Acoustics Measurements Conf, Rhodes 2014.